TRANSLATION (HM-625PCT):

**Translation of WO 2004/044257 A1 (PCT/EP03/10852)
with Amended Pages Incorporated Therein**

METHOD AND DEVICE FOR DESCALING AND/OR CLEANING A METAL CASTING

The invention relates to a method and device for descaling and/or cleaning a metal casting, particularly a hot-rolled strip made of normal steel or of stainless steel which involves guiding the metal casting in a direction of conveyance through a device inside which it is subjected to a plasma descaling and/or plasma cleaning. The invention further relates to a device for descaling and/or cleaning such a metal casting.

A method from a related class is known from JP 03207518 A.

For subsequent processing, for example by cold-rolling, for a metallic coating or the direct finishing to a final product the hot-rolled strip must have a descaled surface. Thus, the scales originating from hot-rolling and during the following cooling must be completely removed. In the afore-mentioned method, this is achieved by means of a pickling process, wherein the scales made of various ferrous oxides (FeO,Fe304, Fe203) or in the case of stainless steel of ferrous metals rich in chromium are dissolved depending on the quality of the steel by means of various acids (for example, hydrochloric acid, sulfuric acid, nitric acid or mixed acid) at high temperatures in a chemical reaction with the acid. Prior to pickling normal steel requires an additional mechanical treatment by means of stretcher-and-roller levelling in order to break open the scales and to allow a quicker permeation of the acid into the scale layer. For stainless, austenitic and ferritic steels which are substantially more difficult to

pickle, an annealing and a mechanical pre-descaling of the strip precedes the pickling process in order to attain the best possible strip surface for pickling. Following descaling the steel strip must be rinsed, dried and if necessary oiled in order to prevent oxidation.

The pickling of steel strip is performed in continuous lines whose process section may exhibit a very sizable length depending on the speed of the conveyance. Such production lines thus require high investments. The pickling process further necessitates a very large amount of energy and high expenditures for the disposal of waste water and the regeneration of hydrochloric acid which is usually used for normal steel.

Therefore, there are various approaches in the state-of-the-art which effect the descaling of metal castings without the deployment of acids.

Hitherto known developments are usually based on a mechanical removal of the scales (for example, Ischiclean method, APO-method). Such methods however are not suited for the industrial descaling of broad steel strip with respect to the efficiency and quality of the descaled surface. For this reason, acids are still deployed for descaling such strips.

The disadvantages relating to efficiency and environmental pollution therefore have been tolerated up to now.

Newer approaches for the descaling of metal casting employ plasma technology. This method is already described in the afore-mentioned JP 03207518 A as well as in WO 00/56949 A1, WO 01/00337 A1, RU 2153025 C1 and RU 2139151 C1. In the plasma-descaling technology disclosed therein the material to be descaled passes between special electrodes which are located in a vacuum chamber. The descaling results by means of the

plasma generated between the steel strip and the electrodes, wherein a metallic bright surface without residue is produced. Plasma technology thus represents an efficient, high-quality and environmentally friendly option for descaling and cleaning steel surfaces. It can be deployed for normal steel as well as for stainless, austenitic and ferritic steel. A special pre-treatment is not required.

The mentioned state-of-the-art is primarily applied to the descaling of wire and pipes. The advantage in this regard is a relatively simple guidance of the electrodes which is possible based on the geometry of the material to be descaled, so that an efficient descaling can be effected.

In the case of descaling steel strip, however it appears that the method disclosed in the mentioned literature does not lead to a practical outcome, i.e., that steel strip treated in such a manner cannot be descaled with the required quality, at least when it exhibits a certain width.

JP 07275920 A indeed discloses a method of this sort, wherein a set of bending rollers is arranged before the plasma-descaling chamber by means which the strip entering the chamber is treated. However, the strip evenness achieved thereby does not suffice to attain the intended quality of descaling.

Thus, the underlying objective of the invention is to create a method and a corresponding device for descaling and/or cleaning of a metal casting with which it is possible to efficiently and effectively descale even wide metal castings over their entire width with consistent quality by means of plasma technology, wherein the economical as well as ecological advantages of this method should be utilizable.

The invention achieves this objective with respect to the method, such that before the plasma descaling and/or a plasma cleaning device, in the direction of conveyance, the metal casting is subjected to a stretcher levelling process or a stretcher-and-roller levelling process which imparts a high degree of flatness to the metal casting.

In this process a tensile force can be exerted on the metal casting to such an extent that the degree of flatness of the metal casting entering the device for plasma descaling and/or plasma cleaning is so high that the casting can pass through the device as flat sheet metal. The result of descaling and/or cleaning is thereby improved dramatically, so that the finished metal strip exhibits a high quality.

It has proven advantageous that during the levelling process the tensile force is selected such that a tensile stress arises in the metal casting which corresponds to at least 10% of the yield point of the metal casting material.

The method can be carried out on continuously conveyed metal casting; however, it is also possible to convey the metal casting through the descaling and/or cleaning machine in a discontinuous manner, i.e., with a varying speed. The last-mentioned case is particularly interesting for smaller lines.

An especially high quality of the finished metal casting can be achieved if the surface of the metal casting is inspected after the device for plasma descaling and/or plasma cleaning; in this case it is intended that the speed with which the metal casting is conveyed through the device for plasma descaling and/or plasma cleaning is specified in a closed-loop control in dependence on the inspection, such that the desired quality of descaling and/or cleaning is attained. Explicitly this means that if the quality of descaling and/or cleaning is still unsatisfactory, the speed of the metal casting conveyed

through the device for plasma descaling and/or plasma cleaning will be decreased, such that the plasma has a longer time to act on the metal casting. This makes it possible to adapt the quality of the descaling and/or cleaning process to special demands.

As a particularly preferential embodiment, the descaling and/or cleaning of the metal casting can be directly followed by a coating of the casting with liquid metal, in particular a hot galvanizing. Known coating techniques can be applied herein. One possibility results in the metal casting being guided through a boiler which is filled with liquid coating metal, wherein a deflection of the metal casting takes place in the boiler. Alternatively, the CVGL-method (Continuous Vertical Galvanizing Line) can also be deployed, by means which the metal casting is guided from the bottom through the a boiler which is filled with liquid metal, wherein the coating metal is retained in the boiler by means of an electomagnetic closure. Following descaling and/or cleaning and prior to coating with liquid metal the metal casting is preferentially heated, preferably by means of induction heating.

The cold-rolling of the metal casting can be advantageously carried out immediately following the descaling and/or cleaning of the metal casting.

The device for descaling and/or cleaning the metal casting has a configuration through which the metal casting is guided in the direction of conveyance and inside which the metal casting is subjected to a plasma descaling and/or plasma cleaning. The device according to the invention is characterized by means which impart a high degree of flatness to the metal casting before the device for plasma descaling and/or plasma cleaning in the direction of conveyance, whereby at least one stretching device is arranged before and/or after the means

for producing a tensile force in the metal casting. These means consist of at least one stretcher levelling or stretcher-and-roller levelling machine. The S-roll stand has proven effective as a stretching device.

A particularly good conveyance of the metal casting through the device for plasma descaling and/or plasma cleaning can be effected if a stretching device is arranged in the direction of conveyance behind the device for plasma descaling and/or plasma cleaning for producing a tensile force in the metal casting, whereby an S-roll stand is also considered preferable in this regard. As a result, the metal casting is kept very flat when passing through the plasma device which increases the quality of the descaling and/or cleaning.

The device for plasma descaling and/or plasma cleaning can exhibit a treatment chamber under vacuum in which a number of modularly built electrodes are arranged in the direction of conveyance of the metal casting. In this regard the individual electrodes can be designed to be switched on or off independently of one another in dependence on the degree of scaling and/or degree of contamination of the surface of the metal casting as well as in dependence on the speed with which the metal casting passes through the plasma device. In this regard, as many electrodes can be switched on for descaling and/or cleaning as are necessary to achieve the desired result.

An additional improvement in the quality of descaling and/or cleaning can be achieved if inspection means for inspecting the surface of the metal casting are arranged in the direction of conveyance behind the device for plasma descaling and/or plasma cleaning; these are connected with control means, wherein these control means set the speed with which the metal casting is conveyed through the device in dependence on the

inspection, so that the desired descaling and/or cleaning quality of the metal casting is achieved.

As previsouly illustrated, the descaling and/or cleaning line according to the present invention can be advantageously deployed in combination with additional treatment devices. Means for coating the metal casting with liquid metal, particularly for hot galvanizing can be arranged in the direction of conveyance behind the device for plasma descaling and/or plasma cleaning. These means can exhibit a boiler for liquid metal and at least one deflection roller integrated therein. Alternatively, the means for coating may exhibit a boiler and under the boiler electromagnetic means for retaining the liquid metal in the boiler. Means for heating the metal casting, in particular induction heating means can be arranged in the direction of conveyance behind the device for plasma descaling and/or plasma cleaning and in the direction of conveyance before the means for coating the metal casting.

As an alternative to or in addition to the coating means, means for rolling the metal casting can be arranged behind the device for plasma descaling and/or plasma cleaning in the direction of conveyance; this can be a multiple stand cold rolling tandem mill.

A continuous operation of the entire line is aided by the fact that a strip storage is arranged in the direction of conveyance before the device for plasma descaling and/or plasma cleaning.

It is further advantageous for the high productivity of the line if means for trimming the metal casting (trimming shears) are arranged in the direction of conveyance behind the device for plasma descaling and/or plasma cleaning.

The productivity of the line is also further improved by the fact that means for oiling the metal casting are arranged in the direction of conveyance behind the device for plasma descaling and/or plasma cleaning.

An overall highly productive line for the processing metal casting, preferably for hot-rolled strip made of normal steel or of stainless steel, is the result which guarantees an economical and ecological descaling and/or cleaning of the metal casting and which has proven effective particularly in combination with subsequent/downstream treatment devices.

The described technology provides great advantages especially compared with pickling with respect to environmental protection, energy conservation and quality. In addition, the investment costs for such lines are considerably less than for known descaling and/or cleaning lines.

Design embodiments of the invention are illustrated in the drawings, wherein:
Fig. 1 schematically shows a device for descaling and for subsequent hot galvanizing of a metal casting,
Fig. 2 schematically shows a device for descaling and for subsequent rolling of the metal casting, and
Fig. 3 schematically shows a device for descaling a metal casting.

Fig. 1 schematically shows a device with which a metal casting 1 can first be descaled and subsequently hot galvanized. The metal casting 1 enters the line with a predetermined speed of conveyance v in the direction of conveyance R and is initially guided between two S-roll stands 5 and 6 which exert a tensile force F on the metal casting 1. A means 4 for stretcher levelling the metal casting 1 is arranged between both S-roll stands 5, 6. This means 4 is a stretcher-and-roller levelling machine.

A schematic outline shows that the metal casting 1 is bent or stretcher levelled by means of adjustable rolls under high tension by the tensile force F in the stretcher-and-roller levelling machine 4, so that the metal casting 1 exhibits a high degree of flatness upon leaving the stretcher-and-roller levelling machine 4.

Following the stretcher-and-roller levelling machine 4 the metal casting 1 is conveyed to the device 2 for plasma descaling and/or cleaning. This device 2 exhibits a treatment chamber 8 which is kept under vacuum. Locks 19 and 20 are each located at the entrance and the exit of the metal casting 1 into and out of the treatment chamber.

An S-roll stand 7 is also arranged in the direction of conveyance behind the device 2; in interaction with S-roll stand 6 it is possible to keep the metal casting 1 under tension (tensile force F) while passing through the device 2, ensuring that the metal casting 1 runs through the device 2 with a high degree of flatness. This is required for attaining a good result with respect to descaling and/or cleaning.

As seen in Fig. 1, a number of electrodes 9 are arranged in the treatment chamber 8 which are required in order to produce the plasma with which the surface of the metal casting 1 is descaled or cleaned. Details relating to this process can be found in the afore-mentioned literature.

Several electrodes 9 are arranged successively in the direction of conveyance R as can be seen in in Fig. 1. These can all be activited simultaneously for descaling and/or cleaning, in other words, powered with electrical energy. It is however also possible to selectively switch the individual modularly built electrodes 9, so that only a number of

electrodes which is necessary for effecting the desired descaling and/or cleaning outcome is activated.

An inspection means 10 is arranged in the direction of conveyance R behind the device 2 for plasma descaling and/or plasma cleaning which is able to inspect the surface of the metal casting 1 and relay the result of the inspection to the control means 11. Depending on the desired quality of descaling and/or cleaning, the control means 11 can be programmed such that it affects the power unit of the entire device, not illustrated herein, in a way that the speed of conveyance v is influenced so that the result of descaling and/or cleaning corresponds to the desired specifications.

If the quality of descaling and/or cleaning is not sufficient, the control means 11 can lower the speed of the conveyance v; the surface of the metal casting is thereby exposed to the plasma for a longer time, whereby the result of descaling and/or cleaning is improved. If the quality is already excessively high and not required, the control means 11 can effect an increase in the speed of conveyance v, so that although the quality of the descaling and/or cleaning is reduced, the productivity of the overall line however is increased.

As additionally seen in Fig. 1, an induction heating means 14 which can heat the metal casting 1 is located in the direction of the conveyance R behind the device 2 for plasma descaling and/or plasma cleaning. In particular, this can be an induction-heated annealing furnace with a protective gas atmosphere with which it is possible to heat the metal casting 1 to a temperature of approximately 500°C within a very short time. Afterwards the metal casting 1 is conveyed in a protective atmosphere and by means of a blowpipe, not shown herein, to a boiler 3 with liquid coating metal. A deflection roll 13 is arranged in the boiler 3 which deflects the metal

casting 1 after coating with the liquid coating metal vertically to the top. The induction heating means 14, the boiler 3 and the deflection roll 13 comprise the schematically illustrated means 12 for coating the metal casting 1.

An alternative embodiment of the line can be seen in Fig. 2. The difference to Fig. 1 resides in the fact that in Fig. 2 means 15 for rolling the descaled and/or cleaned metal casting 1 are arranged downstream of the device 2 for plasma descaling and/or plasma cleaning. In this case the means represent a multiple stand cold-rolling tandem mill, on which the metal casting 1 is rolled to the desired final thickness.

A device is outlined in Fig. 3 which solely serves the descaling of the metal casting 1, but which can also be combined with downstream devices such as those solutions shown in Figs. 1 and 2.

The metal casting 1 is fed in a coiled state from a reel 21 to a welding machine 22 where the metal casting 1 is welded together with the previous metal casting. Prior to welding the strip ends are cut with shears 23 in order to enable flawless welding.

The metal casting 1 is then conveyed to a stretcher levelling machine or a stretcher-and-roller levelling machine 4 in which the casting 1 can be levelled by bending and the application of a tensile force such that it exhibits an optimal flatness prior to entering the device 2 for plasma descaling and/or plasma cleaning. The metal casting initially passes the lock 19 whereupon it is then situated in the treatment chamber 8 which is under vacuum. The vacuum is generated by a vacuum pump 24. Descaling and/or cleaning is carried out in the treatment chamber 8 by means of the plasma located between the electrodes 9 and the metal casting 1. The number of electrodes 9 depends on the strip speed v in order to

guarantee the required dwell time of the metal casting 1 in the plasma.

Following the complete descaling and/or adequate cleaning the metal casting 1 passes through the vacuum lock 20 to the S-roll stand 7 which as already mentioned produces, in interaction with the S-roll stand 6, the a high enough strip tension to enable the most horizontal strip passage possible.

Support rolls 25 are arranged between the electrodes 9 which prevent the sagging of the metal casting 1 within longer treatment chambers 8 and at higher strip speeds v.

The exact width of the metal casting can be attained by means of trimming shears 17.

If necessary, the metal casting 1 is electrostatically oiled by means of the oiling machine 18 in order to protect the surface of the metal casting from corrosion. The metal casting 1 is separated with shears 26 before kicking off the finished coil. It is also possible to work with two reels 21 and 27 each located in the inlet and in the outlet, respectively in order to attain the shortest possible coil changing times.

A continuous strip passage in the process section of the line is made possible with strip storage 16 and strip storage 28. A discontinuous operation without strip storage is possible for lines with low output, wherein the line is stopped while the coil is changed. Contrary to pickling, this is possible for plasma descaling without losses in output.

In the above description, both descaling and cleaning of a metal casting have been mentioned side by side. Plasma technology namely has turned out to be suitable not only for descaling but also very good for the cleaning of organic and inorganic substances (e.g., oil) from metallic surfaces.

Cold-rolled oiled steel strip for example prior to a metal coating must pass through special alkaline and electrolytic cleaning tanks followed by rinsing and in part also by brushing in order to attain the required metallic bright surface. The lines already mentioned also deploy chemical substances for this purpose which raise the environmental concerns previously stated. The application of plasma technology for the cleaning of metal casting also yields great advantages in this regard.

As already mentioned above, great economic advantages result when coupling the line outlined in Fig. 3 with downstream treatment devices according to Figs. 1 and 2. The intermediate storage of descaled and/or cleaned strip can be omitted, so that both production and quality improvements can be effected. The strip storage 28 (see Fig. 3) behind the device 2 for plasma descaling and/or plasma cleaning has special importance in this regard. The descaled and preferably already trimmed strip can then continuously enter the successive device (hot galvanizing line, cold rolling tandem mill) under constant strip tension without intermediate storage.

Following the successive device, in particular behind the cold-rolling tandem mill, the finished strip can be alternately recoiled with two reels and separated with shears.

List of Reference Numbers :

1	Metal casting
2	Device for plasma descaling and/or plasma cleaning
3	Boiler with liquid coating metal
4	Means for levelling the metal casting (stretcher levelling machine, stretcher-and-roller levelling machine)
5	Stretching device (S-roll stand)
6	Stretching device (S-roll stand)
7	Stretching device (S-roll stand)
8	Treatment chamber
9	Electrodes
10	Inspection means
11	Control means
12	Means for coating the metal casting
13	Deflection roll
14	Means for heating the metal casting (induction heating means)
15	Means for rolling the metal casting
16	Strip storage
17	Means for trimming the metal casting (trimming shears)
18	Means for oiling the metal casting (oiling machine)
19	Lock
20	Lock
21	Reel
22	Welding machine
23	Shears
24	Vacuum pump
25	Support roll
26	Shears
27	Reel
28	Strip storage
R	Direction of conveyance
v	Speed of conveyance
F	Tensile force